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Research progress in novel poly-silicon aromatic alkyne based composite with ultra high permittivity

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The modern information revolutions, such as 5G mobile communication, large capacity satellite, wearable electronics, etc. demand billions of laminates with high dielectric constant and low dielectric loss to transmit electrical signals at high frequency as well as high temperature resistance. In this study, a high performance composite for microwave circuit application has been fabricated by filling a thermosetting poly-silicon aromatic alkyne (PSAA) matrix with $Ca_{1-x}La_{2x/3}TiO_3$-based (abbreviated as CLT) ceramic fillers. Firstly, the performance of CLT ceramics were improved by doping with a proper amount of Al_2O_3 (0.28~1.11 mol.%). Particularly, the anti-reduction mechanism of Ti^{4+} in $Ca_{0.9}La_{0.067}TiO_3$ ceramic was carefully investigated. The $Ca_{0.9}La_{0.067}TiO_3$ ceramic doped with 1.11 mol.% Al_2O_3 exhibited good microwave dielectric properties: ε_r = 141, $Q \times f$ = 6848 GHz. Secondly, highly dense and spherical ceramic fillers were produced by granulation followed with sintering process. The particle size distributions of the fillers were 20~50 μm and could be well controlled. At last, a composite was fabricated by filling PSAA matrix with high performance CLT ceramic fillers. The results showed that large-size spherical fillers distributed well throughout the PSAA matrix. The 0.5PSAA-0.5CLT composite exhibited ultra-high dielectric constant of ~16.0, low dielectric loss of 2.5×10^{-3} (at 10 GHz) and kept intact even under temperature of 450 °C.

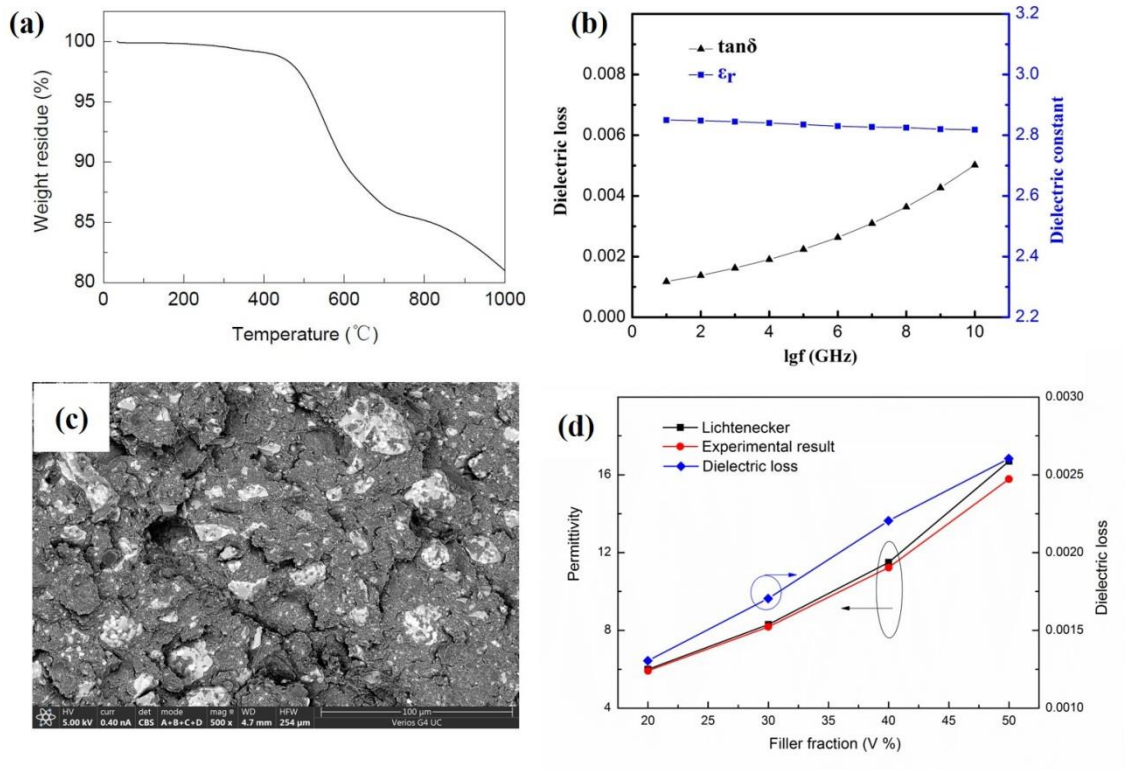

Figure 1. (a) Thermo-gravimetric curve of thermosetting PSAA resin. (b) Dielectric properties of thermosetting PSAA resin with the variation of frequency. (c) SEM photograph of the cross section of 0.5PSAA-0.5CLT composite. (d) Dielectric properties of 0.5PSAA-0.5CLT composite at high frequency.